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CactusTalk: More dragon tree tales

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Deriving inspiration from the dragon tree

A team of researchers at the University of Freiburg and the Karlsruhe Institute of Technology, using high-resolution magnetic resonance imaging techniques, has succeeded in observing how the tissue of a living dragon tree is displaced when subjected to a load. In the future, technical fibre-reinforced lightweight ramifications with structures and behaviour similar to that of the natural model could be used to improve architectural supporting structures, bicycle frames or even car bodies.

Using the Madagascar dragon tree, *Dracaena marginata* (*D. reflexa* var. *angustifolia*) as the plant of choice, scientists began by imaging the inside of a stem and branch in an unloaded state using MRI. They then used a mechanical arm controlled from outside the scanner to bend the branch and again imaged the internal structure. Three-dimensional computer models of the two sets of images were created, which allowed them to compare how tissues that stabilise the plant behave and how they are displaced under a load. The entire stem-branch attachment as well as the individual vascular bundles were observed with great precision, particularly when under a load. Depending on their position in the branch, the bundles and the caps (fibre caps that surround and protect the vascular bundles) stretch lengthwise to absorb a tensile load or are pressed crosswise against the surrounding tissue to cushion it against compressive stress.

Their results and findings will no doubt serve as a basis for developing fibre-reinforced technology. The manufacturing of nodal elements and/or ramifications with an optimised force flow is one of the major challenges in many areas of fibre-reinforced composite technology. Examples are hubs of wind-power plants, branching points of framework constructions in the building industry, aerospace and ramified vein prostheses in medical technology. Addressing this problem requires the adaptation of innovative manufacturing techniques and the implementation of novel mechanically-optimised fibre-reinforced structures, and studies using cacti and succulents can help provide some answers.

LITERATURE:

Hesse, L, Masselter, T, Leipold, J, Spengler, N, Speck, T & Korvink, J G (2016) Magnetic resonance imaging reveals functional anatomy and biomechanics of a living dragon tree. *Scientific Reports* 6: 32685.

DOI:10.1038/srep32685

More dragon tree tales

Pachycaul dragon trees of the genus *Dracaena* have a disjunct distribution, occurring in Macaronesia on the Atlantic Islands and in central Morocco with a vast gap eastwards before they reoccur in East Africa, the Arabian Peninsula and famously on the island of Socotra, where the iconic species *D. cinnabari* is endemic. *Dracaena draco* is the archetypal dragon tree, the most famous specimen of which is at Icod de los Vinos on the island of Tenerife (Fig. 1).

Most of the handful of species are now exceedingly rare in the wild. Consequently, the discovery 20 years ago of a large population of several thousand relatively small trees from inaccessible gorges in the Anti-Atlas Mountains of Morocco, subsequently described as *D. draco* subsp. *ajgal*, was highly significant. Remarkably just a year later, a new and critically endangered species, *D. tamaranae*, was described from the well-botanised island of Gran Canaria.

Since the last synopsis of dragon trees was published (Walker, 2001), three new ones have been described. Firstly, a reassessment of known populations in the Cape Verde Islands led to the description of *D. draco* subsp. *caboverdeana* (Marrero & Almeida Pérez, 2012). Key features of this new taxon are: the shape of the plant with a short trunk and a densely branched canopy, the leaves glaucous blue, and the fruits larger than those of subsp. *draco*. This separation of the subspecies on the Cape Verde Islands leaves subsp. *draco* restricted to the Canary Islands (Gran Canaria, La Palma and Tenerife) and Madeira, where it is critically endangered.



Fig. 1 *Dracaena draco* at Icod de los Vinos, Tenerife, estimated to be at least 1,000 years old. It is now showing signs of its age, but has a recently planted small succulent garden around it, for which visitors are required to pay an entrance fee (Photo: Colin Walker)

As currently understood, *D. serrulata* is endemic to the Arabian Peninsula, whilst the closely related *D. ombet* is restricted to north-east Africa (Sudan, Ethiopia, Eritrea, Djibouti and Somalia). This year two new subspecies of *D. serrulata* have been described. The first of these comes from the Dhofar region of Oman, hence the name *D. serrulata* subsp. *dhofarica* (McCoy & Lavranos, 2017). Again this results from a reassessment of known populations rather than a new discovery. This new subspecies differs from subsp. *serrulata* in having dark green leaves with entire margins; this contrasts with subsp. *serrulata* that was so named because of its toothed leaf margins. The other significant difference is that subsp. *dhofarica* has light pink flowers (strictly the tepals) as opposed to the typical white ones.

Subspecific status for the Dhofar population is appropriate because it is separated from the nearest known representatives of subsp. *serrulata* by about 500km. The typical subspecies occurs in the Yemen and north along the Arabian escarpment in Saudi Arabia (McCoy & Lavranos, 2017). In Oman subsp. *dhofarica* is restricted to the highest dry plateaux, where it appears to be under extreme pressure with little regeneration because of overgrazing, especially by camels and leaf harvesting for fibres. McCoy & Lavranos further report that plants only on steep cliffs retain their normal growth habit and that flowering is very irregular in the wild.

The newest dragon tree is *D. serrulata* subsp. *mccoyorum* (Lavranos, 2017) (Fig. 2). It is distinguished from the typical subspecies in being a large many-branched umbrella-shaped tree 7–8m tall, making it the largest of the three subspecies. Its leaves are very light grey with an entire margin and it has different coloured flowers with tan/beige tepals. This is endemic to Saudi Arabia where it occurs near the summit of a single mountain with unusual geology (composed of tonalite) west of Bishah in the Asir Province, roughly 250km north of the nearest recorded population of subsp. *serrulata*.

This latest dragon tree is named in honour of Tom McCoy's family who have supported him over many decades of field work. The single locality has been visited several times and it is regrettable to report that over 30 years the single population has declined so significantly that only a very few mature specimens remain and it is assessed as being on the brink of extinction. Threats recorded are mostly due to human activities: overgrazing, removal of terminal leaves for fodder and the removal of larger branches, which are cut into sections and then hollowed out to make beehives.

LITERATURE CITED:

Lavranos, J J (2017) A new, arborescent subspecies of *Dracaena* from Saudi Arabia. *Cact. Succ. J. (US)* **89**(4): 148–152.



Fig. 2 *Dracaena serrulata* subsp. *mccoyorum* in its mountain-top habitat in western Saudi Arabia. This is the largest of the three recognised subspecies and differs by its umbrella-shaped growth habit and larger, wider and very light grey leaves (Photo: Tom McCoy)

Marrero, A & Almeida Pérez, R S (2012) A new subspecies, *Dracaena draco* (L.) L. subsp. *caboverdeana* Marrero Rodr. & R. Almeida (Dracaenaceae) from Cape Verde Islands. *Int. J. Geobotanical Res.* **2**: 35–40.

McCoy, T & Lavranos, J (2017) Beobachtungen zu drei neuen Arten bzw. Unterarten von Dhofar-Xerophyten und ihre Beschreibungen/Observations on three new species or subspecies of Dhofari xerophytes and their descriptions. *Avonia* **35**: 54–67.

Walker, C C (2001) *Dracaena* in Eggl, U (ed) *Illustrated Handbook of Succulent Plants – Monocotyledons*. Springer Verlag, Berlin, etc, pp 259–261.

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DNA sequencing in the field

In a recent paper published in *Scientific Reports*, researchers at the Royal Botanic Gardens, Kew, detail for the first time the opportunities for plant sciences that are now available with portable, real-time DNA sequencing. Using a hand-held DNA sequencing device they conducted the first genomic plant sequencing in the field in a fraction of the time of traditional methods, offering exciting possibilities to conservationists and scientists.

Kew scientist and co-author of the paper Joe Parker says, "This research proves that we can now rapidly read the DNA sequence of an organism to identify it with minimum equipment. Rapidly reading DNA anywhere, at will, should become a routine step in many research fields. Despite hundreds of years of taxonomic research, it is still not always easy to work out which species a plant belongs to just by looking at it."

Over the last forty years, DNA sequencing has revolutionised the scientific world but has remained laboratory-bound. Using current methods, a complete experiment to identify a species, from fieldwork to result, could easily take a scientist months to complete. Species

identification is, by nature, largely a field-based area of pursuit, thereby limiting the pace of discovery and decision-making that can depend upon it. Using new technology to identify species quickly and on-site is critical for scientific research, the conservation of biodiversity and in the fight against species crime.

In this new study, Kew scientists used the portable DNA sequencer, the MinION from Oxford Nanopore Technologies, to analyse plant species in Snowdonia National Park. This was the first time genomic sequencing of plants had been performed in the field. This technology, commercially launched in 2015, has since been used in Antarctica, in remote regions affected by disease, and on the International Space Station.

One of the successes illustrated in the paper is the field identification of two white-flowering plants, *Arabidopsis thaliana* and *Arabidopsis lyrata* subsp. *petraea*. This was achieved by sequencing random parts of the plants' genomes, avoiding the tricky and time-consuming process of targeting specific pieces of DNA, which is the more traditional approach for identifying species with DNA. The researchers compared their new data to a freely available database of reference genome sequences to make their identification.

There are other useful properties of their data too. This field-sequenced data can be used to assemble a whole genome sequence, act as a reference database for the species and help understand evolutionary relationships. Currently, the team is exploring the feasibility of rapidly generating a reference sequence database from the incredibly diverse collection of plants held in Kew's living collection and herbarium, as well as applications for monitoring plant health.



Fig. 3 The portable field laboratory used for the research (Photo: Joe Parker)

It was not that long ago that cactus and succulent explorers started using GPS devices in the field, so the day when they start using hand-held DNA sequencing devices in order to distinguish between species may not be that far off!

LITERATURE:

Parker, J, Helmstetter, A J, Devey, D, Wilkinson, T & Papadopoulos, A S T (2017) Field-based species identification of closely-related plants using real-time nanopore sequencing. *Scientific Reports* 7(1) DOI: 10.1038/s41598-017-08461-5

***Mammillaria pectinifera* at risk**

Mammillaria pectinifera is an endemic, short-globose cactus, included in the IUCN list as a threatened species with only 18 remaining populations in the Tehuacán-Cuicatlán valley in central Mexico. A recent study has evaluated the population genetic diversity and structure, connectivity, recent bottle-necks (a sudden decrease in the

size of a population with corresponding reduction of total genetic variability) and population size, using nuclear micro-satellites. *M. pectinifera* showed high genetic diversity but some evidence of heterozygote deficiency, recent bottle-necks in some populations and reductions in population size. Also, low population genetic differentiation and high values of connectivity were found for *M. pectinifera*, as the result of historical events of gene flow through pollen and seed dispersal.



Fig. 4 *Mammillaria pectinifera* (Photo: Marco Sisti)

M. pectinifera occurs in sites with some degree of disturbance, leading to the isolation of its populations and decreasing the levels of gene flow among them. Excessive deforestation also changes the original vegetation damaging the natural habitats. This species will become extinct if it is not properly preserved. Furthermore, this species has some ecological features that make them more vulnerable to disturbance, such as very low growth rates and long life cycles. In situ conservation is suggested to prevent the decrease of population sizes and loss of genetic diversity in the natural protected areas, such as the Tehuacán-Cuicatlán Biosphere Reserve. In addition, a long-term ex situ conservation programme is needed to construct seed banks, and optimise seed germination and plant establishment protocols that restore disturbed habitats. Additionally, creating a supply of living plants for the trade is critical to avoid further extraction of plants from nature.

LITERATURE:

Maya-García, R, Arizaga, S, Cuevas-Reyes, P, Peñaloza-Ramírez, J M, Ramírez, V R & Oyama, K (2017) Landscape genetics reveals inbreeding and genetic bottlenecks in the extremely rare short-globose cacti *Mammillaria pectinifera* (Cactaceae) as a result of habitat fragmentation. *Plant Diversity* 39:13–19.

Over-wintering cacti in the UK

I first started to collect cacti and succulents when I was still living at home with my parents in a little terrace house with a minuscule garden. I bought myself an all round glass garden frame. This had a wooden framework which required a coat of white lead paint every year. (How times change!) The floor was made up of wooden planks elevated on bricks while the whole frame was lined with polythene. During the winter it was heated by a small paraffin lamp with an old piece of carpet in reserve in case of exceptional frosts.

When I got married my wife made me a present of a greenhouse and so the plants were moved into it, where there was plenty of light and air. In fact one cactus (name unknown) then flowered for the first and (up until now) the only time. During the winter the plants were tucked away in a new aluminium frame which had been lined with bubble wrap. The small heater was again brought into use and the old carpet put on standby. Eventually some of the plants became too big for the frame, so some were moved into the conservatory as winter quarters. These included a *Senecio articulatus* var. *globosus* which flowered at Christmas with small flowers which smelled like cat's wee. This was not the best move that I had made!

One winter I accidentally left some duplicates in the greenhouse, which was lined with bubble-wrap. These plants were dry and covered with fleece. They survived OK and so, the next winter, I took a chance and left a few more in that position. The only casualty was a tall unnamed *Opuntia* with 50mm spines which decided to



Fig. 5 English mini cactus and succulent garden (Photo: Jim Baldwin)

bend in half after -7°C of frost. I had little sympathy for it since it had once fallen on me when I was alone in the greenhouse during the summer. "Ouch" was an understatement and I questioned its parentage!

I have continued with this winter arrangement to this day without any problems but I also had a large greenhouse heater on standby just in case. By way of an experiment I decided to see if I could get any cacti or succulents to survive outside by using some duplicates. So I found a spot in the shingle garden which was always in full sun and dug a small trench. The bottom was lined with corks and then the hole filled with builder's aggregate which the pots were then sunk into. Around the edges of the hole I built a low dry-stone wall. Before winter the plants were covered with fleece and a pane of glass was balanced on the wall to keep out the rain. By next spring it was uncovered and all was well; in fact an *Aloe* decided to flower.

This has been an interesting exercise over the years and the only plants that I have lost have been because of my over-watering in the late summer so that they sat wet throughout the winter.

Jim Baldwin
Fakenham, Norfolk

Hurricanes and British Virgin Islands

In the September issue (*CactusWorld* 35(3)) we featured an article about 'Developing ex situ conservation in the British Virgin Islands'. As you may be aware, the article was already at the printers when Hurricane Irma hit the island. Since then Hurricane Maria also caused further damage. A communication from Dr Martin Hamilton of Kew received at the end of September states, "We are in communication with our colleagues in BVI. The situation is dire. The garden has been all but destroyed. We are developing plans to assist the recovery over the coming months and years, but we are at very early stages as there is still a humanitarian crisis. I'll let you know about possible next steps once things are clearer."